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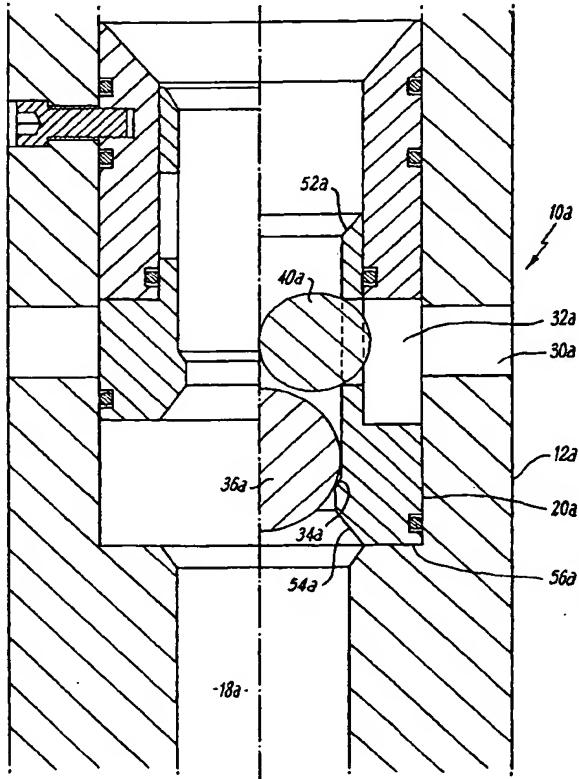
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(54) Title: DOWNHOLE CIRCULATION VALVE OPERATED BY DROPPING BALLS



(57) Abstract: A downhole tool (10) for selectively circulating fluid in a borehole is disclosed. The tool operates via the use of a combination of deformable drop balls (36) and smaller hard drop balls (40). In use a deformable drop ball (36) moves a sleeve (20) exposing a radial port (30,32) to provide fluid circulation radially from the tool. The smaller drop ball (40) can then obstruct the radial port (32,30) and by the increased pressure the deformable drop ball (36) is extruded through the tool. The resulting pressure differential as the drop ball (36) moves causes the sleeve (20) to rise, releasing the smaller drop (40) ball and closing the radial port (32,30). The process can be repeated to selectively circulate fluid through the tool.



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DOWNHOLE CIRCULATION VALVE OPERATED BY DROPPING BALLS

1 Downhole Tool

2

3 This invention relates to apparatus and method for
4 circulating fluid in a borehole.

5

6 It is known that this operation can be achieved by
7 employing a downhole tool connected on a drill string.
8 The tool includes means for circulating fluid through the
9 length of the drill string and also redirecting the fluid
10 at higher flow rates out of the drill string onto the
11 walls of the borehole.

12

13 Such tools are of at least two generic types. One type
14 of tool is a weight-set tool. Such a tool comprises a
15 tubular assembly connected to the drill string and
16 includes a general axial fluid outlet, a generally
17 transversed fluid outlet and an obturating member which
18 is moveable between a first position and a second
19 position at which the transverse fluid outlet is open.
20 The obturating member is moved relative to the tubular
21 assembly by extending or collapsing the tool, the latter
22 movement occurring by causing a shoulder coupled to the
23 obturating member to engage with a formation in the

1 borehole. Such tools have the disadvantage that they
2 require contact to a formation within the borehole, thus
3 a ledge or formation must exist within the borehole.

4

5 A second type of circulation tool utilises the well known
6 practice of dropping spherical balls or darts down the
7 drill string to open or close valves, thereby alternating
8 the circulation paths of fluid. The main disadvantage of
9 these tools is that it is difficult to control both axial
10 and radial fluid flow from a single spherical ball.

11 There is also known difficulties in achieving release of
12 the ball so that axial fluid may be established through
13 the drill string.

14

15 An object of the present invention is to provide an
16 improved downhole tool for fluid circulation, which
17 obviates or at least mitigates some of the disadvantages
18 of the prior art.

19

20 A further object of the present invention is to provide
21 an improved downhole tool for fluid circulation which can
22 be repeatably operated downhole.

23

24 A yet further object of the present invention is to
25 provide an improved downhole tool for fluid circulation
26 which is operated by fluid pressure and does not require
27 the incorporation of springs.

28

29 According to a first aspect of the present invention
30 there is provided a downhole tool for circulating fluid
31 within a borehole, the tool comprising:

32

33 a tubular assembly having an axial through passage

1 between an inlet and a first outlet, a second outlet
2 extending generally transversely from the tubular
3 assembly and the through passage including a lower ball
4 retaining means;

5

6 an obturating member including an upper ball retaining
7 means, the obturating member being moveable relative to
8 the tubular assembly between a first position closing the
9 second outlet and a second position at which the second
10 outlet is open; and

11

12 first ball means being retainable within said upper and
13 said lower ball retaining means to prevent fluid flow
14 between the inlet and first outlet and the first ball
15 means being deformable under increased fluid pressure to
16 pass through said upper and said lower ball retaining
17 means.

18

19 Preferably the tool further includes second ball means
20 wherein the second ball means is of a size which when
21 located in the second outlet prevents fluid flow
22 therethrough.

23

24 Preferably the ball means is a spherical drop ball. More
25 preferably the first ball means has a larger diameter
26 than the second ball means.

27

28 Preferably also the first ball means is made from an
29 extrudable material, such as a plastic or phenolic
30 material.

31

32 Preferably the second ball means is made from a hard
33 material, such as steel or the like.

1

2 Preferably the upper and lower ball retaining means is a
3 generally circular shoulder or ledge. Thus the first ball
4 means seats on the ball retaining means preventing fluid
5 flow between the inlet and first outlet. When fluid
6 pressure increases the first ball means is extruded by
7 deforming through the ball retaining means.

8

9 Preferably the obturating member is a sleeve. More
10 preferably the sleeve includes a radial port.

11

12 Additionally the sleeve may be coupled to a collet. The
13 collet allows the sleeve to be releasably engaged to the
14 tubular assembly. The collet also allows the radial port
15 to remain aligned with the second outlet by preventing
16 the sleeve from turning within the tubular assembly.

17

18 Preferably the tool further includes catching means for
19 catching the ball means once they have passed through the
20 ball retaining means. Such a catching means allows the
21 balls to be collected and returned from the well once the
22 tool has finished its operations.

23

24 According to a further aspect of the present invention,
25 there is provided a method of circulating fluid in a
26 borehole comprising the steps of:

27

28 (a) connecting a downhole tool, according to the first
29 aspect of the present invention, in a drill string
30 suspended in the borehole;

31

32 (b) establishing fluid flow through the axial through
33 passage of the tool;

1

2 (c) releasing the first ball means into the axial

3 through passage to seat in the upper ball retaining

4 means thereby obstructing the axial fluid flow

5 through the tool;

6

7 (d) moving the obturating member by the increase of

8 fluid pressure against the first ball means to

9 locate the radial port with the second outlet

10 thereby allowing fluid flow through the second

11 outlet;

12

13 (e) releasing the second ball means from the surface,

14 such that the second ball means locates in the

15 radial port thereby obstructing the fluid flow

16 through the second outlet;

17

18 (f) forcing the first ball means passed the upper

19 ball retaining means by the increase in pressure so

20 as to locate the first ball means in the lower ball

21 retaining means, the first ball means falling a

22 distance comparatively short enough to ensure

23 sufficient pressure to move the obturating member

24 back up the tubular assembly thereby closing the

25 radial port and releasing the second ball means; and

26

27 (g) allowing the fluid pressure to increase to a

28 sufficient pressure to cause the first ball means to

29 pass through the lower ball retaining means and the

30 second ball means to follow therethrough and allow

31 axial fluid flow to be re-established.

32

33 Preferably the method also includes catching the ball

1 means in a catching means at the bottom of the tool.

2

3 An advantage of the method of the present invention is
4 that the steps may be repeated any number of times to
5 provide circulation of fluid through the tool.

6

7 In order to provide a better understanding of the
8 invention, embodiments will now be described, by way of
9 example only, with reference to the following Figures, in
10 which:

11

12 Figures 1 through 4 are sequential part cross-sectional
13 views through a downhole tool according to a first
14 embodiment of the present invention; and

15

16 Figure 5 is a part cross-sectional view through a
17 downhole tool according to a second embodiment of the
18 present invention.

19

20 Referring initially to Figure 1, there is shown a top
21 section of a downhole tool, termed a circulating tool and
22 generally referred to by reference numeral 10, according
23 to a first embodiment of the present invention. The
24 circulating tool 10 comprises a tubular assembly 12
25 having a first end 14 including a screw thread connection
26 16 to connect the circulating tool 10 to a drill string
27 (not shown). Tubular assembly 12 includes an axial
28 through passage 18. When located in a borehole the tool
29 section shown in Figure 1 is closest to the surface.

30

31 Reference is now made to Figure 2 of the drawings which
32 depicts a further section of the circulating tool 10 in a
33 downward direction from the surface. Inside tubular

1 assembly 12 is located the obturating member 20 in the
2 form of a sleeve 20. Sleeve 20 is coupled to a collet 22
3 which is slidable against an inner sleeve 24 of the
4 tubular assembly 12. Inner sleeve 24 is held in place by
5 a retaining pin or grub screw 26. Collet 22 can move
6 longitudinally against inner sleeve 24, and can
7 releasably engage in circular recess 28. Sleeve 20, inner
8 sleeve 24 and the outer wall of the tubular assembly 12
9 are each provided with sealing means in the form of o-
10 rings to prevent the ingress of fluid therebetween.

11

12 Reference is now made to figure 3 of the drawings which
13 depicts a further section of the circulation tool 10. In
14 this embodiment sleeve 20 includes port 32 which when
15 sleeve 20 is in an open position aligns with a radial
16 port 30 in the tubular assembly 12. In this open position
17 sleeve 20 is located against shoulder 38 of tubular
18 assembly 12. A first spherical ball 36 is located against
19 a shoulder 34 of the sleeve 20 which retains the ball 36
20 as fluid flows via ports 30 and 32. A second spherical
21 ball 40 is shown located in port 30 thereby closing the
22 fluid flow radially from the tool 10. It will be
23 apparent that when collet 22 is located in recess 28 the
24 sleeve 20 is in the closed position, obturating the
25 outlet port 30.

26

27 In tubular assembly 12 there is also located seat 42
28 which is of a diameter sufficient to retain ball 36.
29 When ball 36 is extruded through seat 42 it is caught in
30 catcher 44 and prevented from flowing through the drill
31 string by the peg 46. Ball 40 can pass cleanly through
32 seats 34, 42 and will come to rest in the ball catcher 44.

33

1 Reference is now made to figure 4 of the drawings which
2 illustrates ball catcher 44 including balls 36a,b and
3 40a,b. It will be appreciated that the location of pin 46
4 will determine how many balls may be retained in the ball
5 catcher 44. The location of the balls 36a,b 40a,b does
6 not obstruct fluid flow through axial through passage 18
7 and out of first outlet 48. Outlet 48 includes connection
8 means 50 in the form of a screw thread for connecting the
9 circulation tool 10 to a further downhole drill
10 string(not shown).

11

12 In use, tool 10 is attached in a drill string with the
13 sleeve 20 held in the closed position which obturates
14 outlet port 30. The sleeve 20 is held in this closed
15 position by the location of collet 22 in recess 28.

16

17 To operate the tool 10, ball 36 is dropped down the axial
18 through passage in the fluid flow and comes to rest
19 against shoulder 34. Ball 36 seals against shoulder 34
20 and blocks fluid flow through the tool 10. The fluid
21 pressure pushes ball 36 and consequently sleeve 20 in the
22 axial direction of fluid flow through passage 18. Sleeve
23 20 comes to rest against shoulder 38 and radial port 32
24 is aligned with the outlet port 30. Fluid flow is now
25 radially from the tool via port 30. This radial flow can
26 be of high pressure as the port 30 may be of a small
27 diameter or be shaped as a jet (not shown).

28

29 When the radial fluid flow is required to be stopped a
30 second ball 40 is dropped into the passage 18 at the
31 surface. Ball 40 is carried in the fluid and forced
32 against port 32 thereby sealing the radial port 30. Ball
33 40 is made of steel to withstand the downhole pressure

1 exerted upon it. However, the consequential increase in
2 fluid pressure in the passage 18 causes ball 36, which is
3 made of a deformable plastic, to be extruded through the
4 seat 34. Ball 36 is then forced against lower seat 42 and
5 because the distance between the seats 34 and 42 is
6 relatively small, i.e. approximately 6 inches for ball
7 diameters of 2 inches and 1.75 inches and inner passage
8 diameter of 3.75 inches, the resulting pressure
9 differential at the base of the sleeve 20 causes the
10 sleeve 20 to move upwards to the closed position. As the
11 sleeve 20 moves upwards ball 40 is released into the
12 axial fluid flow and falls through seat 34.

13

14 With radial port 30 now closed, all fluid pressure is
15 substantially against ball 36 and the ball 36 is extruded
16 by deforming through the seat 42 and falls into the ball
17 catcher 44. Ball 36 is held within the ball catcher 44 be
18 the retaining pin 46. Ball 40 falls through seat 42 and
19 is also held within the ball catcher 44.

20

21 If radial flow is required again the above procedure may
22 be repeated without the need for removing the tool 10
23 from the borehole. This procedure may be repeated until
24 the ball catcher is full whereby the tool is returned to
25 the surface for the catcher 44 to be emptied.

26

27 Reference is now made to Figure 5 of the drawings which
28 depicts a section of the circulation tool 10a in
29 accordance with a second embodiment of the present
30 invention. Like parts to those of Figures 1 to 4 have
31 been given the same numerals but are suffixed "a". Tool
32 10a works in an identical fashion to tool 10 except that
33 collet 22 has been removed. In the second embodiment,

1 sleeve 20a is arranged such that surface 52 is smaller
2 than surfaces 54 and 56 which ensures that sleeve 20a
3 moves up to and remains in the closed position without
4 the need of the collet 22.

5

6 The principal advantage of the present invention is that
7 it may be operated solely by hydraulic pressure of the
8 fluid within the borehole, the tool requires no springs
9 or locking/engaging means to move the obturating member.

10 A further advantage of the present invention is that
11 circulation of the fluid can be selectively started and
12 stopped any of number of times and is only dependent on
13 the available space in the ball catcher mechanism at the
14 base of the tool is used. Thus this removes the need for
15 shearing mechanisms found in other fluid circulating
16 tools.

17

18 It will be appreciated by those skilled in the art that
19 various modifications may be made to the present
20 invention without departing from the scope thereof. For
21 example the ball means could equally be darts or any
22 other shaped objects which will travel through the fluid
23 and locate in the ball retaining means.

1 CLAIMS

2

3 1. A downhole tool for circulating fluid within a
4 borehole, the tool comprising:

5

6 a tubular assembly having an axial through passage
7 between an inlet and a first outlet, a second outlet
8 extending generally transversely from the tubular
9 assembly and the through passage including a lower
10 ball retaining means;

11

12 an obturating member including an upper ball
13 retaining means, the obturating member being
14 moveable relative to the tubular assembly between a
15 first position closing the second outlet and a
16 second position at which the second outlet is open;
17 and

18

19 first ball means being retainable within said upper
20 and said lower ball retaining means to prevent fluid
21 flow between the inlet and first outlet and the
22 first ball means being deformable under fluid
23 pressure above a first pressure to pass through said
24 upper and said lower ball retaining means.

25

26 2. A downhole tool as claimed in Claim 1 wherein the
27 tool further includes second ball means wherein the
28 second ball means is of a size which when located in
29 the second outlet prevents fluid flow therethrough.

30

31 3. A downhole tool as claimed in Claim 1 or Claim 2
32 wherein the ball means is a spherical drop ball.

33

- 1 4. A downhole tool as claimed in Claim 2 or Claim 3
2 wherein the first ball means has a larger diameter
3 than the second ball means.
4
- 5 5. A downhole tool as claimed in any preceding Claim
6 wherein also the first ball means is made from an
7 extrudable material, which is deformable under a
8 pressure above the first pressure.
9
- 10 6. A downhole tool as claimed in any of Claims 2 to 5
11 wherein the second ball means is made from a hard
12 material, which is not deformable.
13
- 14 7. A downhole tool as claimed in any preceding Claim
15 wherein the upper and lower ball retaining means are
16 substantially circular shoulders arranged so that
17 the first ball means seats on the ball retaining
18 means preventing fluid flow between the inlet and
19 first outlet until the first pressure is reached
20 whereupon the first ball means is extruded by
21 deforming through the ball retaining means.
22
- 23 8. A downhole tool as claimed in any preceding Claim
24 wherein the obturating member is a sleeve.
25
- 26 9. A downhole tool as claimed in Claim 8 wherein the
27 sleeve includes a radial port.
28
- 29 10. A downhole tool as claimed in any preceding Claim
30 wherein the obturating member is coupled to a collet
31 so that it is releasably engaged to the tubular
32 assembly.
33

1 11. A downhole tool as claimed in Claim 10 when
2 dependent on Claim 9 wherein the radial port remains
3 aligned with the second outlet by virtue of the
4 collet.

5

6 12. A downhole tool as claimed in any preceding Claim
7 wherein the tool further includes catching means for
8 catching the ball means once they have passed
9 through the ball retaining means.

10

11 13. A method of circulating fluid in a borehole,
12 comprising the steps of:

13

14 (a) connecting in a drill string in a borehole, a
15 tubular assembly including an axial through
16 passage and a radial port;

17

18 (b) dropping a first ball into the axial through
19 passage to rest within the axial through
20 passage below the radial port thereby causing
21 fluid in the through passage to be directed
22 through the radial port;

23

24 (c) dropping a second ball into the axial through
25 passage to rest in the radial port and prevent
26 fluid flow through the tool; and

27

28 (d) by increased fluid pressure, moving the first
29 ball in the through passage, the movement of
30 the first ball causing a pressure differential
31 sufficient to move a member, closing the radial
32 port and releasing the second ball into the
33 through passage.

1 14. A method of circulating fluid in a borehole
2 comprising the steps of:

3

4 (a) connecting a down hole tool, according to any
5 one of Claims 9 to 12, in a drill string
6 suspended in the borehole;

7

8 (b) establishing fluid flow through the axial
9 through passage of the tool;

10

11 (c) releasing the first ball means into the axial
12 through passage to seat in the upper ball
13 retaining means thereby obstructing the axial
14 fluid flow through the tool;

15

16 (d) moving the obturating member by the increase of
17 fluid pressure against the first ball means to
18 locate the radial port with the second outlet
19 thereby allowing fluid flow through the second
20 outlet;

21

22 (e) releasing the second ball means from the
23 surface, such that the second ball means
24 locates in the radial port thereby obstructing
25 the fluid flow through the second outlet;

26

27 (f) forcing the first ball means passed the upper
28 ball retaining means by the increase in
29 pressure so as to locate the first ball means
30 in the lower ball retaining means, the first
31 ball means falling a distance comparatively
32 short enough to ensure sufficient pressure to
33 move the obturating member back up the tubular

1 assembly thereby closing the radial port and
2 releasing the second ball means; and

3

4 (g) allowing the fluid pressure to increase to a
5 sufficient pressure to cause the first ball
6 means to pass through the lower ball retaining
7 means and the second ball means to follow
8 therethrough and allow axial fluid flow to be
9 re-established.

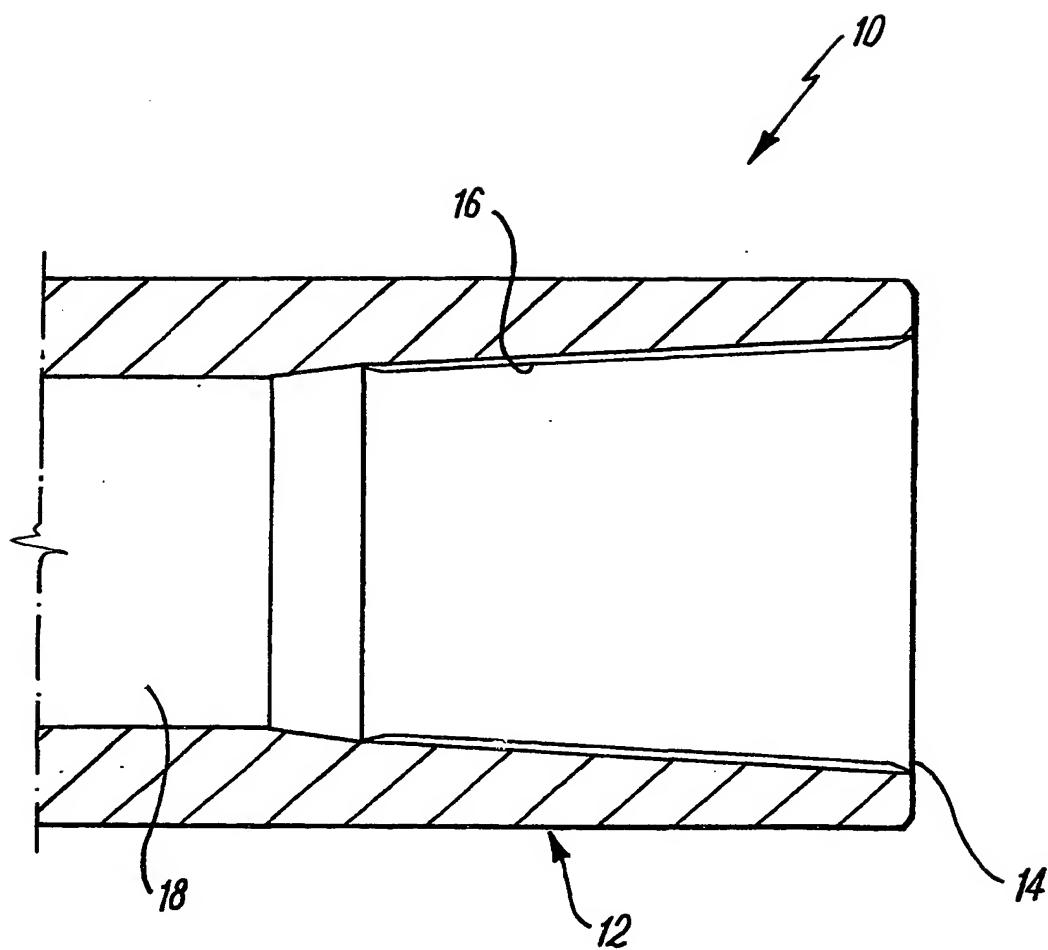
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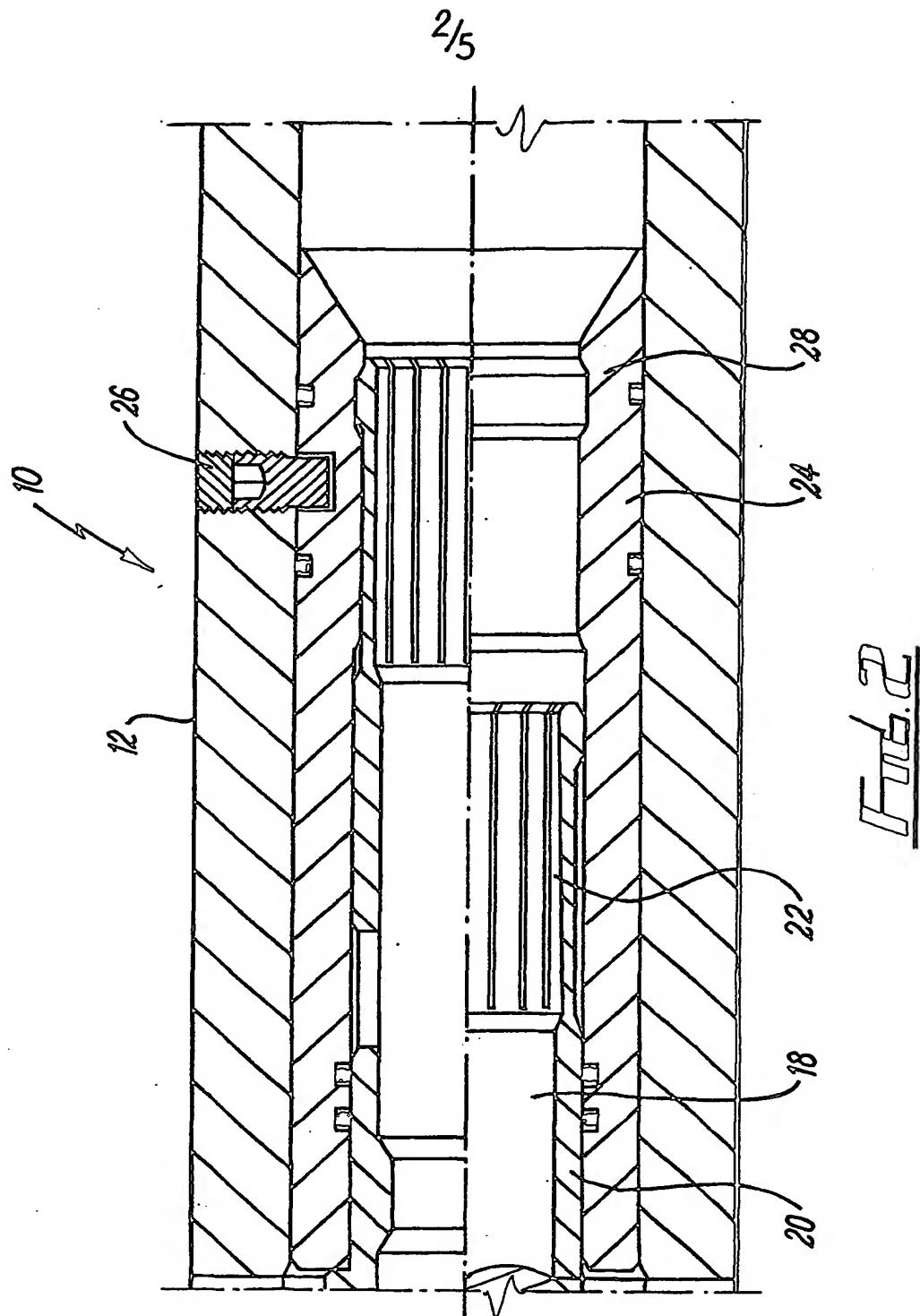
11 15. A method of circulating fluid in a borehole as
12 claimed in Claim 13 or 14 including the step of
13 catching the ball means in a catching means at the
14 bottom of the tool.

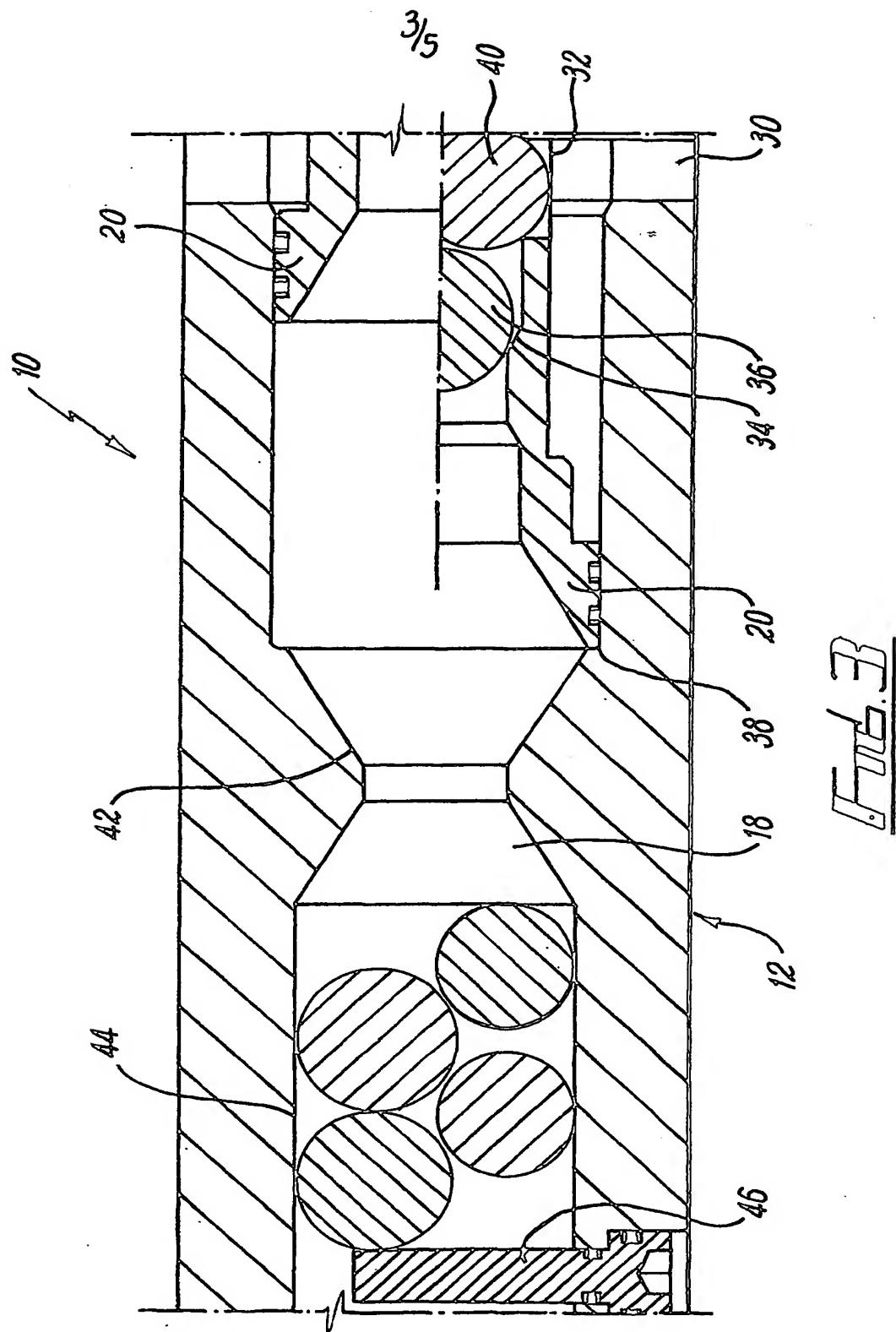
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16 16. A method of circulating fluid in a borehole as
17 claimed in any of Claims 13 to 15 wherein the steps
18 are repeated to provide selected circulation of
19 fluid when the tool is in the borehole.

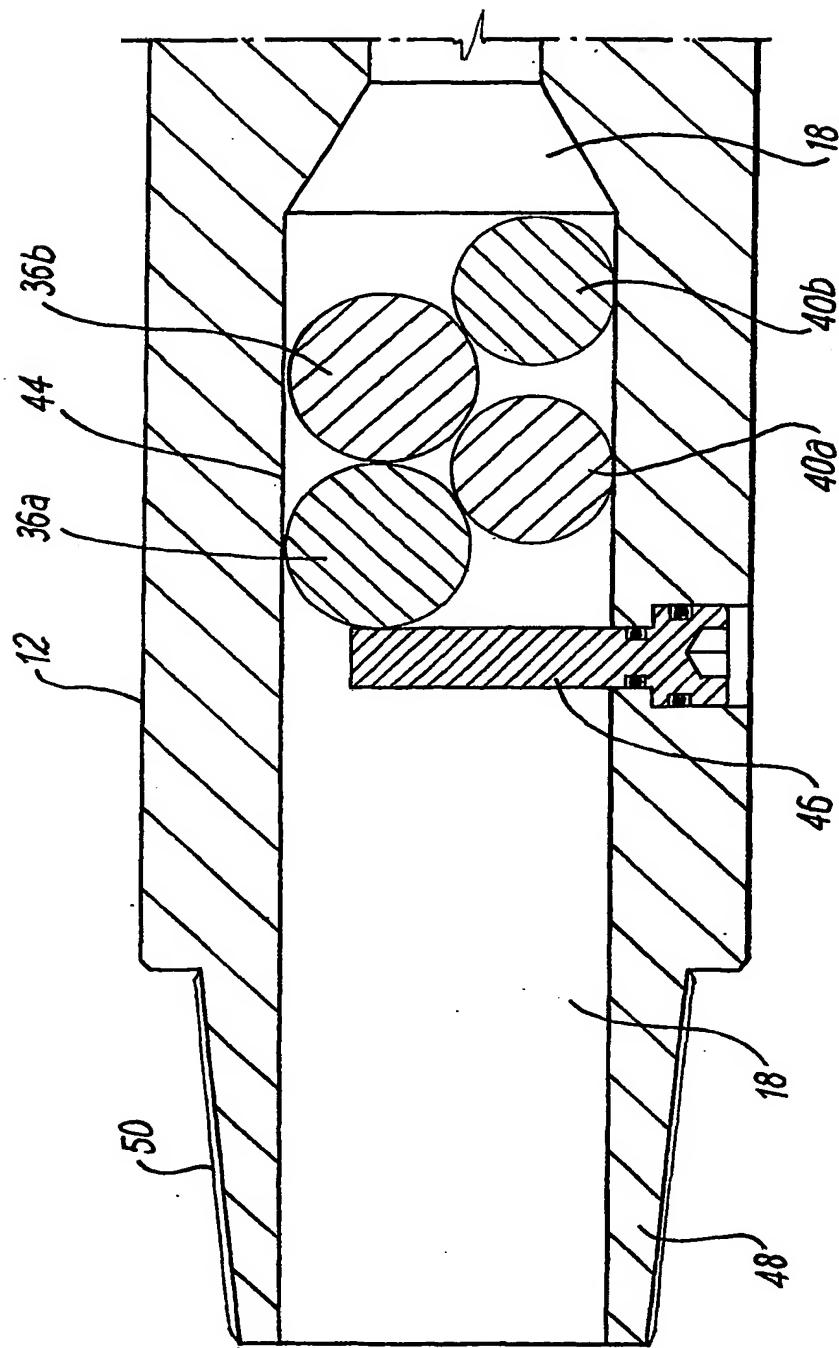
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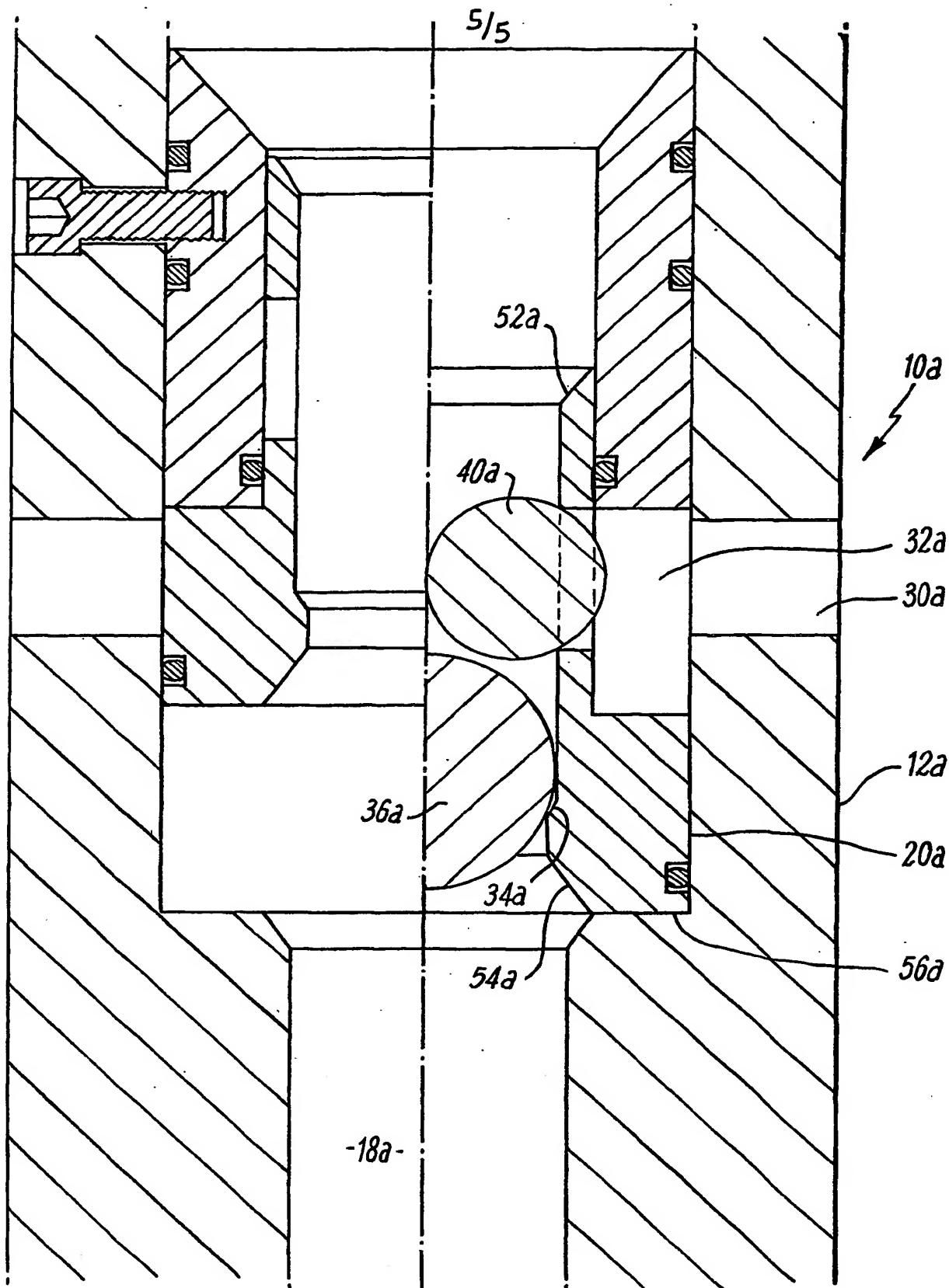
FIG. 1





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FIG. 4

**FIG. 5**

INTERNATIONAL SEARCH REPORT

Intel 7al Application No
PCT/GB 02/00083

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B21/10 E21B34/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	GB 2 341 405 A (SPECIALISED PETROLEUM SERV LTD) 15 March 2000 (2000-03-15) figures 1-6 ---	1-9, 14
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
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- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the International search

30 May 2002

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06/06/2002

Name and mailing address of the ISA

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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